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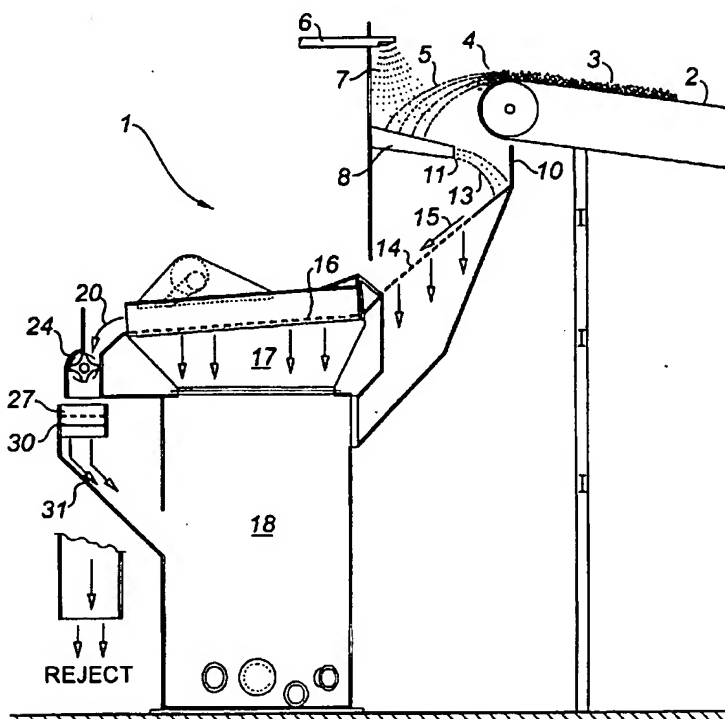
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(54) **MISE EN SUSPENSION EPAISSE DE SABLE BITUMINEUX  
POUR HYDROTRANSPORT EN PIPELINE**

(54) **SLURRYING OIL SAND FOR HYDROTRANSPORT IN A  
PIPELINE**



(57) Un circuit de mélange, sous forme de composantes

(57) A mixer circuit, in the form of a vertically oriented





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superposées, fonctionne en vue de mettre en suspension épaisse du sable bitumineux avec de l'eau en vue de son pompage dans un pipeline. Le sable bitumineux tombe initialement du bout d'un convoyeur. Il est mis en contact à mi-hauteur avec un jet d'eau pour que l'eau se distribue dans la masse du sable bitumineux et le mouille. Le mélange est déversé dans une auge inclinée vers le bas. L'eau et le sable bitumineux se mélangent pendant qu'ils se déplacent avec turbulence dans l'auge à bout ouvert. La suspension épaisse est dispersée à sa sortie de l'auge et étalée en une mince couche sur un tablier. Elle est ensuite acheminée sur des tamis pour rejet des fragments trop gros. La suspension tamisée tombe dans une boîte de pompage. Les fragments rejetés sont affinés dans un impacteur placé au bout des tamis. Le sable bitumineux affiné est tamisé pour enlèvement des fragments trop gros qui restent et les sables bitumineux affinés et tamisés sont déversés dans la boîte de pompage. L'installation est compacte et la perte par rejet de fragments trop gros est relativement faible.

stack of components, functions to slurry oil sand with water in preparation for pumping through a pipeline. The oil sand is initially dropped from the end of a conveyor. It is contacted in mid-air with a stream of water to distribute the water through the oil sand and to wet the latter. The mixture drops into a downwardly slanted trough. The water and oil sand mix as they move turbulently through the open-ended trough. The slurry is deflected as it leaves the trough and is spread in the form of a thin sheet on an apron. It is then fed over screens to reject oversize lumps. The screened slurry drops into a pump box. The rejected lumps are comminuted in an impactor positioned at the end of the screens. The comminuted oil sand is screened to remove remaining oversize lumps and the screened comminuted oil sands are delivered into the pump box. The structure is compact and the oversize reject loss is relatively low.



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**"SLURRYING OIL SAND FOR HYDROTRANSPORT  
IN A PIPELINE"**

**ABSTRACT OF THE DISCLOSURE**

A mixer circuit, in the form of a vertically oriented stack of components, functions to slurry oil sand with water in preparation for pumping through a pipeline. The oil sand is initially dropped from the end of a conveyor. It is contacted in mid-air with a stream of water to distribute the water through the oil sand and to wet the latter. The mixture drops into a downwardly slanted trough. The water and oil sand mix as they move turbulently through the open-ended trough. The slurry is deflected as it leaves the trough and is spread in the form of a thin sheet on an apron. It is then fed over screens to reject oversize lumps. The screened slurry drops into a pump box. The rejected lumps are comminuted in an impactor positioned at the end of the screens. The comminuted oil sand is screened to remove remaining oversize lumps and the screened comminuted oil sands are delivered into the pump box. The structure is compact and the oversize reject loss is relatively low.

**FIELD OF THE INVENTION**

This invention relates to a process and mixer circuit for mixing oil sand with water to produce a slurry which can be pumped through a pipeline.

**BACKGROUND OF THE INVENTION**

The McMurray oil sands of Alberta constitute one of the largest deposits of hydrocarbons in the world.

At the present time, there are two very large scale plants extracting bitumen (a heavy and viscous oil) from these oil sands. Each of these plants incorporates a sequence of mining, bitumen extraction and bitumen upgrading operations.

For many years, the as-mined oil sand was moved by conveyor belt assemblies from the mine site to the extraction plant.

In recent years, slurry pipelines have begun to replace the conveyor belt systems.

In connection therewith, one needs to provide suitable means for slurring the oil sand with water and entrained air, to produce a slurry that is suitable for pumping down the pipeline.

The mixer circuit so provided is required to cope with very large volumes of throughput - typically 10,000 tons of oil sand per hour. The oil sand is highly erosive, so the mixer circuit should have minimal moving parts and be very durable. In addition, the as-mined oil sand contains a variety of lumps including rocks, clay lumps, and oil sand lumps. The concentration of lumps is greater in winter, when some of the oil sand reports in the form of frozen chunks. Usually the as-mined oil sand will have passed through a double roll crusher prior to slurring, to reduce lump

1 size below 24 inches. However, the crushed oil sand still contains oversize lumps  
2 which are unsuitable for pumping and feeding into the pipeline. Therefore the mixer  
3 circuit requires some means for rejecting the oversize lumps (otherwise referred to  
4 herein as "oversize").

5 In United States patent No. 5039227, issued to Leung et al and  
6 assigned to the owners of the present application, one mixer circuit for this purpose  
7 has been disclosed.

8 In the Leung et al mixer circuit, an oil sand stream is dropped from the  
9 end of a conveyor into a mixer tank. The mixer tank is open-topped, has a cylindrical  
10 body and conical bottom and forms a central bottom outlet. A swirling vortex of slurry  
11 is maintained in the tank and the incoming oil sand is fed into it. Slurry leaves the tank  
12 through the bottom outlet, is screened using vibrating screens to reject oversize, and  
13 is temporarily collected in an underlying pump box. Some of the slurry in the pump  
14 box is withdrawn and pumped back through a return line to be introduced tangentially  
15 into the mixer tank to form the swirling vortex. The balance of slurry in the pump box  
16 is withdrawn and pumped into the pipeline.

17 The Leung et al mixer circuit has been successfully applied on a  
18 commercial scale. However, it is characterized by certain shortcomings.

19 One problem has to do with the fact that a large proportion of the  
20 produced slurry has to be pumped back into the mixer tank to maintain the vortex. As  
21 a result, the slurry volume that undergoes screening is about twice the volume  
22 pumped into the pipeline. This requires provision of a very large screen area. The  
23 screens are necessarily located in confined quarters. As a result, one cannot increase  
24 the throughput of the circuit because the screens constitute a bottleneck that is not  
25 easily resolved.

1                    Another problem lies in the oversize reject rate. At present the screens  
2 reject lumps having a diameter greater than 2 inches. About 10% of the oil sand feed  
3 is so rejected. These rejects represent a significant oil loss. To reduce this loss, the  
4 rejects are conveyed to a second mixer circuit and are re-processed. This is expensive  
5 to implement.

6                    From the foregoing, it is apparent that there is a need for a mixer circuit  
7 which operates without slurry recycle and which has improved reject rates.

8                    It is the purpose of the present invention to provide such a mixer circuit.

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#### 10                    **SUMMARY OF THE INVENTION**

11                    In a preferred form of the invention, we have provided a stack of  
12 vertically oriented components which convey the oil sand and water downwardly along  
13 a generally zig-zag path, comprising:

- 14                    • A conveyor having a discharge end for delivering a continuous  
15 stream of oil sand that falls through air into a trough;
- 16                    • A pipe for delivering a stream of water which contacts and wets  
17 the falling oil sand in mid-air;
- 18                    • The trough being downwardly slanted, open-topped and  
19 positioned in spaced relation below the conveyor discharge end  
20 and the water pipe. The trough is operative to receive the  
21 mixture of oil sand and water and confine it temporarily to allow  
22 the oil sand and water to turbulently mix and form a slurry stream  
23 as they flow along its length and discharge from its open lower  
24 end;

- An upstanding wall positioned adjacent the trough's lower end and spaced therefrom so that the slurry stream hits it and is deflected, with the result that its direction of flow is changed and further mixing is induced;
- An apron providing a broad surface for receiving the deflected stream, whereby the stream is spread out and thinned to form a slurry sheet adapted to efficiently utilize the screen area;
- A first screen assembly for receiving and screening the slurry sheet to reject oversize and produce a screened slurry stream; and
- A pump box for collecting the screened slurry stream and feeding a pump to deliver the slurry into the pipeline.

This assembly has successfully been tested to demonstrate:

- that a slurry suitable for pipeline conveyance can be formed using only the amount of water required for hydrotransport in the pipeline; and
- that the screen area required for each unit volume of oil sand treated is reduced in comparison to our prior art system.

It has been found that the water needs to contact the curtain of falling oil sand in mid-air. If the water is added at the trough, it has a tendency to channel through the oil sand and mixing is inadequate. The oil sand then does not flow easily along the trough. It has been found that contacting the oil sand in mid-air with water yields good distribution of the water in the oil sand and produces a slurry that flows easily on contacting the trough surface.

1           In a preferred extension of the invention, the rejected oversize lumps  
2 from the first screen assembly are fed directly into an impactor and comminuted. The  
3 comminuted product is screened by a second screen assembly to reject any remaining  
4 oversize. The comminuted, screened product is then delivered into the same pump  
5 box which receives the screened slurry from the first screen assembly.

6           As a result of combining components in this way, the following  
7 improvements have been achieved:

- 8           • the vertical stacking of the components yields a structure that is  
9           compact relative to the prior assembly and relies on gravity to  
10          mobilize the oil sand and water;
- 11          • the need for recycling slurry has been eliminated, with the result  
12          that screen loading is decreased; and
- 13          • reject rates have been reduced below 3%.

14          Broadly stated, in one aspect the invention comprises a process for  
15 slurring oil sand, containing oversize lumps, with water to produce a slurry and  
16 removing oversize lumps from the slurry to produce slurry suitable for pumping through  
17 a pipeline, comprising: dropping the oil sand through air from the discharge end of a  
18 conveyor onto a downwardly slanted surface spaced below the conveyor discharge  
19 end; contacting the oil sand with a stream of water as the oil sand moves through the  
20 air between the conveyor discharge end and the surface, to wet the oil sand; mixing  
21 the oil sand and water as they move together along the surface, to form a slurry  
22 stream; discharging the slurry stream onto first screen means and screening it to reject  
23 oversize lumps; and directing the screened slurry into a pump box prior to pumping it  
24 into a pipeline.



1 Broadly stated, in another aspect the invention comprises an assembly  
2 of vertically oriented components for slurring oil sand, containing oversize lumps, with  
3 water to produce a slurry and removing oversize lumps from the slurry to produce  
4 slurry suitable for pumping through a pipeline, comprising: conveyor means, having  
5 a discharge end, for delivering and dropping a stream of oil sand; a downwardly  
6 slanted surface positioned in spaced relation below the conveyor means discharge end,  
7 so that the oil sand drops thereon; means for delivering a stream of water so that it  
8 contacts and wets the oil sand as it drops between the conveyor means discharge end  
9 and the support surface; whereby the oil sand and water may mix as they move along  
10 the surface and form a slurry stream; first screen means for screening the slurry stream  
11 to reject oversize lumps and produce screened slurry; and pump box means for  
12 receiving the screened slurry.

#### 13 14 DESCRIPTION OF THE DRAWINGS

15 Figure 1 is a schematic side view showing the preferred embodiment of  
16 the invention.

#### 17 18 DESCRIPTION OF THE PREFERRED EMBODIMENT

19 As-mined oil sand to be pipelined is first crushed before conveying it to  
20 a mixer circuit 1. This is commonly done by passing it through a set of double rolls,  
21 producing 24 inch product. This pre-treatment (which forms no part of the invention)  
22 is done to break down the very large contained lumps.

23 The crushed oil sand contains lumps of varying size and composition.

24 The mixer circuit 1 comprises a series of downwardly arranged  
25 components.

1                   The uppermost component is a conveyor 2 for continuously delivering a  
2 stream of crushed oil sand 3. The oil sand cascades or falls from the discharge end  
3 4 of the conveyor 2 - it drops downwardly through an air space 5.

4                   A horizontal pipe 6 is positioned opposite to the conveyor discharge end  
5 4. The pipe discharges a stream 7 of water into the falling oil sand in mid-air at a  
6 sufficient rate so that the water/oil sand ratio is equivalent to that of the pipeline slurry.  
7 Typically this ratio is about 1:3 by weight. The stream 7 contacts the downwardly  
8 descending oil sand is distributed through it and wets it.

9                   The oil sand and water drop into a downwardly slanted, open-topped,  
10 open-ended trough 8. The trough is formed of plate steel.

11                   As the oil sand and water move through the trough, they mix turbulently  
12 and form a slurry.

13                   A solid, vertical wall 10 formed of steel is positioned adjacent the lower  
14 end 11 of the trough 8. The wall 10 is spaced from the trough's lower end 11 and  
15 extends across the trajectory path of the slurry stream 13 discharging from the trough.

16                   A downwardly slanted apron 14 extends downwardly from the wall 10 in  
17 a direction opposite to that of the trough 8.

18                   The slurry stream 13 hits the wall 10, is deflected and changes its  
19 direction of movement, being discharged onto an apron 14 having solid and then  
20 apertured portions. In the course of these movements, further turbulent mixing of the  
21 oil sand and water occurs. On reaching the apron, the slurry spreads out laterally and  
22 is thinned, to form a slurry sheet 15. Some slurry drops through the apertures into the  
23 pump box 18.

24                   The slurry sheet 15 flows from the apron 14 onto a contiguous first  
25 vibrating screen 16. It is sized to retain +4 inch material.

1                   The slurry 17 passing through the screen drops into a pump box 18.

2       Here the slurry is collected and temporarily retained before being pumped from an  
3       outlet into a pipeline (not shown).

4                   The oversize lumps 20 retained by the vibrating screen 16 are delivered  
5       into an Impactor 24. The lumps 20 are largely oil sand in composition and many  
6       disintegrate when impacted by the rotating arms of the impactor, producing  
7       comminuted product 27. This product discharges from the outlet of the impactor onto  
8       a second vibrating screen 30. The screened comminuted product is discharged  
9       through hopper 31 into pump box 18. The oversize lumps retained by the screen 30  
10      are discarded.

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**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE  
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

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1. A process for slurring oil sand, containing oversize lumps, with water to produce a slurry and removing oversize lumps from eth slurry to produce slurry suitable for pumping through a pipeline, comprising:

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dropping the oil sand through air from the discharge end of a conveyor onto a downwardly slanted surface spaced below the conveyor discharge end;

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contacting the oil sand with a stream of water as the oil sand moves through the air between the conveyor discharge end and the surface, to wet the oil sand;

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mixing the oil sand and water as they move together along the surface, to form a slurry stream;

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discharging the slurry stream onto first screen means and screening it to reject oversize lumps; and

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directing the screened slurry into a pump box prior to pumping it into a pipeline.

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2. The process as set forth in claim 1 wherein:

the initial portion of the downwardly slanted surface is provided by an open-topped trough having a discharge outlet at its lower end.

1                   3. The process as set forth in claim 2 comprising:  
2                   discharging the slurry stream from the trough and deflecting the stream  
3                   with upstanding wall means to change its direction of flow and induce further mixing  
4                   of the slurry; and  
5                   spreading the deflected slurry stream over a downwardly slanted apron  
6                   extending from the wall means, to establish a sheet of slurry which is discharged onto  
7                   the first screen means.

8  
9                   4. The process as set forth in claims 1, 2 or 3 comprising:  
10                  comminuting rejected oversize lumps discharged from the first screen  
11                  means, to produce comminuted product;  
12                  and discharging the comminuted product into the pump box.

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14                  5. The process as set forth in claims 1, 2 or 3 comprising:  
15                  comminuting rejected oversize lumps discharged from the first screen  
16                  means, to produce comminuted product associated with residual oversize lumps;  
17                  screening the comminuted product to reject residual oversize lumps; and  
18                  discharging the comminuted product into the pump box.

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1                   6. An assembly of vertically oriented components for slurring oil sand,  
2 containing oversize lumps, with water to produce a slurry and removing oversize lumps  
3 from the slurry to produce slurry suitable for pumping through a pipeline, comprising:  
4                   conveyor means, having a discharge end, for delivering and dropping a  
5 stream of oil sand;  
6                   a downwardly slanted surface positioned in spaced relation below the  
7 conveyor means discharge end, so that the oil sand drops thereon;  
8                   means for delivering a stream of water so that it contacts and wets the  
9 oil sand as it drops between the conveyor means discharge end and the support  
10 surface;  
11                  whereby the oil sand and water may mix as they move along the surface  
12 and form a slurry stream;  
13                  first screen means for screening the slurry stream to reject oversize  
14 lumps and produce screened slurry; and  
15                  pump box means for receiving the screened slurry.

16  
17                  7. The assembly as set forth in claim 6 comprising:  
18                  means for comminuting the rejected oversize lumps as they leave the  
19 first screen means to produce comminuted product; and  
20                  means for transferring the comminuted product into the pump box means.

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22                  8. The assembly as set forth in claim 7 comprising:  
23                  second screen means for screening the comminuted product to reject  
24 residual oversize lumps before the comminuted product is transferred into the pump  
25 box means.

1                    9. An assembly of vertically oriented components for slurring oil sand,  
2       containing oversize lumps, with water to produce a slurry and removing oversize lumps  
3       from the slurry to produce slurry suitable for pumping through a pipeline, comprising:  
4                    conveyor means, having a discharge end, for delivering and dropping a  
5       stream of oil sand;  
6                    a downwardly slanted, open-topped trough having a discharge opening  
7       at its lower end, said trough being positioned in spaced relation below the conveyor  
8       means discharge end, so that the oil sand drops therein;  
9                    means for delivering a stream of water so that it contacts and wets the  
10      oil sand as it drops between the conveyor means discharge end and the trough;  
11                   whereby the oil sand and water may mix as they move through the  
12      trough and form a slurry stream discharging from its lower end;  
13                   wall means, spaced from the trough's lower end, for deflecting the slurry  
14      stream and changing its direction of flow and spreading the stream to form a sheet of  
15      slurry;  
16                   first screen means for screening the slurry stream to reject oversize  
17      lumps and produce screened slurry;  
18                   pump box means for receiving the screened slurry;  
19                   means for comminuting the rejected oversize lumps as they leave the  
20      first screen means to produce comminuted product;  
21                   second screen means for screening the comminuted product to reject  
22      uncomminuted oversize lumps and produce screened comminuted product; and  
23                   means for transferring the screened comminuted product into the pump  
24      box means.

The diagram illustrates a complex mechanical sorting apparatus. At the top right, a large rotating drum (4) is positioned against a curved surface (3). Material flows from the drum through a series of chutes and conveyors. A horizontal conveyor (2) leads into a curved chute (3), which then feeds into a larger hopper-like structure (16). Inside this hopper, there are several downward-pointing arrows (17) indicating the flow path. To the left of the main hopper, there's a smaller component (20) with a circular opening (24) and a vertical shaft (27). Below this, a reject bin (18) is shown, labeled "REJECT". The entire system is supported by a frame, with various structural elements labeled with numbers 1 through 31. A dashed line labeled "I-I" indicates a cross-section plane.